



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 1 of 23
REV: 0.0
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THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

CONTENTS

| | |
|-------|--|
| 1.0 | SCOPE AND APPLICATION |
| 2.0 | METHOD SUMMARY |
| 3.0 | SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE |
| 4.0 | INTERFERENCES AND POTENTIAL PROBLEMS |
| 5.0 | EQUIPMENT/APPARATUS |
| 6.0 | REAGENTS |
| 7.0 | PROCEDURES |
| 7.1 | Preparation |
| 7.2 | Sampling for Mercury |
| 7.2.1 | Sample Mode |
| 7.2.2 | Survey Mode |
| 7.3 | Operating on Battery Power |
| 7.4 | Operating on a Power Supply or AC Power |
| 7.4.1 | Model 411 |
| 7.4.2 | Model 431 |
| 7.5 | Preventive Maintenance Calendar |
| 7.6 | Calibration and Functional Test Procedures |
| 7.6.1 | Model 411 |
| 7.6.2 | Model 431 |
| 8.0 | CALCULATIONS |
| 9.0 | QUALITY ASSURANCE/QUALITY CONTROL |



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 2 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

CONTENTS (cont'd)

10.0 DATA VALIDATION

11.0 HEALTH AND SAFETY

12.0 REFERENCES

13.0 APPENDICES

A - Calibration Check Troubleshooting

B - Functional Test Troubleshooting

C - Material Safety Data Sheets

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U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 3 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe the operation, maintenance and functional test procedures for the Arizona Instrument Corporation, Jerome Division, Models 411 and 431 Gold Film Mercury Vapor Analyzers.

Both the Jerome Models 411 and 431 Mercury Vapor Analyzers, are designed for the analysis of mercury vapor in the workplace environment and for the identification of the location of mercury spills. Both instruments display results digitally, in units of milligrams of mercury per cubic meter of air, (mg Hg/m^3). These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

The Jerome Models 411 and 431 Gold Film Mercury Vapor Analyzers both employ the same principle of operation. Metallic mercury present in an air sample is passed over a thin gold film which undergoes an increase in electrical resistance proportional to the mass of mercury in the sample. The gold film is selective in its adsorption of elemental mercury, thus; eliminating interferences common to ultra-violet (UV) mercury analyzers such as water vapor, particulates, cigarette smoke, and organic solvents. The Model 431 also includes a scrubber and acid gas filter in line with the gold film sensor to remove any acidic gases, which interfere with the sensor's response to mercury. Both models have a scrubber in line to capture mercury released during the regeneration of the Gold Film Sensor.

Both instruments may be operated in either a **SURVEY** or **SAMPLE** mode. The **SAMPLE** mode produces optimum accuracy with both instruments. The **SURVEY** mode is used to assess areas of potentially high mercury contamination.

Activating either the **SAMPLE** or **SURVEY** mode starts an internal pump which draws a precise volume of air over the Gold Film Sensor. The sensor adsorbs and integrates the mercury vapor and the measured concentration is then displayed on the digital meter in units of mg Hg/m^3 .

As mercury adsorbs on the sensor, the percentage of sensor saturation is displayed on the Model 411 by pressing the **SENSOR STATUS** button [with the 431 Model, the percentage saturation is represented during sampling on the digital display with a series of four horizontal bars, each illuminated bar representing an increase in sensor saturation from 0 to 25% (one bar) to 75-100% (four bars)]. Approximately 40 samples containing 0.1 mg Hg/m^3 may be taken with the Jerome Model 411, operating in the **SAMPLE** mode, before the



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 4 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

sensor reaches saturation, while approximately 65 samples, of the same concentration of mercury, can be taken with the Model 431 prior to saturation of the sensor. Following sensor saturation, the sensor must be regenerated using a heating cycle (15 minutes for the 411 Model and 10 minutes for the 431 Model) prior to the analysis of any additional samples. During the heating cycle, mercury desorbed from the sensor, is removed from the instrument flow system by a final scrubber, preventing contamination from the desorbed mercury.

The Model 411 portable instrument will operate approximately five hours on fully charged batteries, while the Model 431 will operate for approximately six hours. With both models, the **SAMPLE** mode provides an integrated, direct reading of mercury vapor concentration in units of mg/m^3 . The **SURVEY** mode allows quick checks to locate high concentration areas. The instrument's microprocessor automatically re-zeroes the digital meter at the start of each sample cycle and freezes the meter reading until the next sample cycle is activated; thus, eliminating drift between samples.

DIRECTORY OF DIGITAL METER DISPLAY CODES

| <u>Digital Meter Display</u> <u>Model Number</u> | | <u>Explanation</u> |
|---|------------|---|
| <u>411</u> | <u>431</u> | |
| .000 | .000 | Ready to Sample, or, Lack of Mercury reading. |
| .H.H.H | .H.H.H | Sensor Regeneration in Progress (.H.H.H Flashes). |
| .8.8.8 | .8.8.8 | For Model 411, Press SENSOR STATUS. If Digital Meter Displays 100, the Gold Film Sensor is Saturated. No Further Operation is Possible Until a Film Heat is Performed. If Digital Meter Does Not Read 100, the Sample was Over Range. Further Operation is Possible With Samples of Lower Concentration, or With the Use of a Dilution Module. For Model 431, Perform Sensor Regeneration. |



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 5 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

| <u>Digital Meter Display</u> <u>Model Number</u> | | <u>Explanation</u> |
|---|------------|--|
| <u>411</u> | <u>431</u> | |
| LO BAT | LO BAT | Recharge Batteries. |
| .L.L.L | .L.L.L | For Model 411, Bridge Balance is Low. Perform Heat Cycle and Adjust Bridge Balance After Cycle. For Model 431, Perform Re-Zero. |
| | .P.P.P | Power Cord Required |
| | . HL | High Level, Sample Exceeded Maximum Sample Limit. |
| <u>For 411 When Sensor Status Button Depressed</u> | | |
| . 10 | | 10% Sensor Saturation |
| . 50 | | 50% Sensor Saturation |
| .100 | | 100% Sensor Saturation - Film Heat Required |
| <u>For 431 During Sampling</u> | | |
| | . - | 0 - 25% Sensor Saturation |
| | . -- | 25 - 50% Sensor Saturation |
| | . --- | 50 - 75% Sensor Saturation |
| | . ---- | 75 - 100% Sensor Saturation |
| <u>For Model 431 When Zero is Depressed (this applies only after a Sensor Regeneration)</u> | | |
| | . 0 | Zero, Ready to Sample |
| | . H | High, Turn Zero Pot Counterclockwise |
| | . L | Low, Turn Zero Pot Clockwise |



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 6 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

- The presence of acid gases in the sampled air stream may cause interferences.
- Organic mercury compounds, such as dimethylmercury, will interfere with the measurement of metallic vapor phase mercury.

5.0 EQUIPMENT/APPARATUS

The following equipment is required for the operation of the Jerome Models 411 and 431.

- Instruction Manuals (For Model 411 OR Model 431)
- Power Cord (6000-4003, Same for both Models)
- Battery Charger (4000-1003 for Model 411; 4000-1011 for Model 431)
- Spare Battery Pack Assembly (Z4000-0901 for Model 411; Z4000-0907 for Model 431)
- Small Screwdriver for adjustments
- Tygon tubing - One foot of 1/4" I.D.
- Dosimeter Lead Set (2100-6005 for Model 411; 2100-6017 for Model 431)
- Data Logger Interface Cable (For Model 431 - 6000-1056)
- Data Logger (For Model 431 - 6100-0010)
- Jerome Communications Interface Software (For the Data Logger and Model 431, S/N 200,306)
- Trimmer Tool (2300-0001, Same for both Models)
- Extension Probe, used to locate mercury vapor in hard to reach places (1400-2002, Same for both Models)
- Zero Air Filter (Z2600-3905, Same for both Models)
- Scrubber Filters (2 for Model 431 - Z2600-3930)
- Intake Filter Disks (13 mm for Model 411 - 2600-3001; 0.25" for Model 431 - 2600-3039)
- C/M Filter (2600-3928 for Model 431)
- Hg Exhaust Filter (A2600-3918 for Model 411)
- Tubing Adapter (1400-3010, Same for both Models)

Note: Battery Recharge requires 16 hours for Model 411 and 14 hours for Model 431.

6.0 REAGENTS

The Vapor Calibration Kit for Model 411 and the Functional Test Kit for Model 431 both contain liquid metallic mercury. No other reagents are required.

7.0 PROCEDURES



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 7 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

7.1 Preparation

Check out and ensure the proper operation of the Gold Film Mercury Vapor Analyzer by performing the following steps:

1. Press **POWER ON**. [Digital meter displays **.000**. (Disregard digital meter's momentary readings.) Recharge or replace the battery pack if the **LO BAT** indicator remains on.]
2. Perform **FILM HEAT** (Model 411) or **SENSOR REGENERATION** (Model 431). For Model 411, press and hold down the **SENSOR STATUS** and adjust the **BRIDGE BALANCE** until the digital meter reads between **02** and **06**. For Model 431, while pressing **ZERO**, turn the **ZERO ADJUST** until the digital meter reads **.0**.
3. Press **SAMPLE**. The Model 411 digital display will show E01 through E09 during the 10 second sample collection. At the end of the 10 second cycle, the digital meter displays the mercury concentration in mg/m^3 . The Model 431 digital meter displays a bar (-) which indicates the amount of sensor saturation and at the end of its 12 second cycle, the digital meter displays the mercury concentration in mg/m^3 .
4. The digital meter display will read between 0.003 and 0.000 if the Analyzer is operating properly.

7.2 Sampling for Mercury

After performing a **FILM HEAT** or **SENSOR REGENERATION**, allow the instrument to stabilize for 20 minutes to ensure maximum sample accuracy.

7.2.1 Sample Mode

The **SAMPLE MODE** produces optimum accuracy and is the recommended sampling mode for routine monitoring.

1. Press **SAMPLE**.
2. At the end of the sampling cycle read the digital meter. The number displayed at the completion of the sampling cycle is the mercury concentration in units of mg/m^3 . The digital meter automatically zeroes at the start of each sampling cycle.
3. For the Model 411, occasionally check the **SENSOR STATUS**. For the Model 431, the bar or bars shown on the digital display during the sampling cycle, indicate the current percentage of sensor saturation. When the sensor is completely saturated, the digital meter displays **.8.8.8** instead of a value. This indicates **SENSOR REGENERATION** must be performed.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 8 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

4. Press power **OFF** when sampling activities are completed and the instrument will not be used.

7.2.2 Survey Mode

The **SURVEY MODE** does not provide accurate analysis of mercury concentrations. This mode is to be used to locate mercury spills or to assess areas of potentially high mercury concentrations.

For Model 411

1. Press **SURVEY**.
2. Read digital meter.
3. Occasionally check **SENSOR STATUS**.
4. Press power **OFF** when sampling activities are completed and the instrument will not be used.

For Model 431

1. Press and ***hold*** **SAMPLE**. The instrument takes a normal sample, displays the concentration and then goes into **SURVEY MODE**. The display flashes the concentrations approximately every three seconds.
2. When you are finished surveying, ***release*** **SAMPLE**. The final survey value remains displayed until the next sample is taken.
3. Approximately 650 samples at mercury concentrations of 0.1 mg/m³ may be collected before a sensor regeneration is required.
4. Press power **OFF** when sampling activities are completed and the instrument will not be used.

A probe may be plugged directly into the instruments intake to aid in locating mercury vapor in hard to reach places. The Jerome Models 411 and 431 are intended for vapor use only. **DO NOT** allow the probe or the instrument's intake to come in contact with liquids, dust or other foreign material.

7.3 Operating on Battery Power

Battery power facilitates operation of the Jerome Models 411 and 431 as portable instruments. If



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 9 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

battery power is necessary for your use, please be aware of the following:

2. A fully charged battery pack provides power for 5 continuous hours of operation for Model 411 and 6 hours for Model 431.
3. For operations lasting longer than 5 or 6 hours, additional fully charged battery packs are required.
4. If **LO BAT** appears in the digital display, replace the battery pack.
5. Complete battery recharging requires 14 to 16 hours.

7.4 Operating on a Power Supply or AC Power

The Jerome Models 411 and 431 employ different mechanisms to permit stationary use using AC power.

7.4.1 Model 411

For stationary use, the optional Continuous Operation Power Supply Kit (COPS) is available. The COPS kit eliminates the need for the battery pack and its necessary maintenance. Use the following installation steps:

1. Unplug the line cord.
2. Remove the two side screws from the digital meter end of the instrument and open the case lid.
3. Locate the battery jacks on the right side of the instrument, toward the rear (with the sampling end of the instrument facing forward). Unplug and remove the battery pack from the instrument.
4. Plug the jumper assembly into the instrument battery jack, close the case lid and replace the two side screws. [The jumper assembly is included with the COPS kit.]
5. The power supply can now be plugged into the battery charger receptacle on the rear of the Model 411. [When the power supply line cord is plugged into an AC source, the instrument is ready for use.]

WARNING!!! With the COPS jumper assembly installed in the Model 411, the battery charger should not be plugged into the charging jack. The battery charger does not supply adequate current to operate the instrument and damage to the instrument and/or battery charger will result.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 10 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

7.4.2 Model 431

For stationary use, the Model 431 may be operated on AC power. If preferred for this type of use, the battery pack may be unplugged and removed completely. Operating the instrument only on AC power eliminates the need for the battery pack and its necessary maintenance.

7.5 Preventive Maintenance Calendar

To keep the Jerome Models 411 and 431 operating at peak performance, follow this maintenance schedule:

- | | | |
|----|---|--|
| 1. | Charge Batteries | After one month of storage, at the end of day's use, or when LO BAT appears. Replace batteries when they no longer maintain their charge. |
| 2. | Change Intake Filter Disc | Weekly or as needed. |
| 3. | Change Internal Filters (Model 431) | After six months of use or as needed. |
| 4. | Change Mercury Exhaust Filter (Scrubber) | Annually |
| 1. | Replace Zero Air Filter | Annually |
| 2. | Perform Calibration (Model 411) Or Functionality Check (Model 431) | After 20 hours of use or Every Three months. |
| 3. | Send out for Factory Calibration | Annually |

NOTE: Plug the **ZERO AIR FILTER** into the instrument's intake during storage.

7.6 Calibration and Functional Test Procedures

7.6.1 Model 411

The purpose of the calibration check, as part of the routine maintenance program, is to verify proper operation of the instrument. If calibration check results fall within the expected range, you may assume the instrument is maintaining its calibration. The Vapor Calibration Kit, part number Y411-0902, is required for this procedure.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 11 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

NOTE: The calibration check should only be performed after a **FILM HEAT**.

Procedure:

1. Leave calibration vessel at stable room temperature for at least 2 hours. [Temperature range for the calibration check is 18 - 22 °C. Temperature fluctuations during the calibration check procedure will produce erratic results.]
2. Unplug line cord and battery charger.
3. Replace intake filter disc.
4. Check flow rate.
5. Replace septum.
6. Plug septum assembly into the instrument's intake.
7. Attach **ZERO AIR FILTER** to septum assembly.
8. Press **POWER ON**.
9. Note temperature of calibration vessel.
10. Inject 1 cubic centimeter (cc) of mercury vapor.
11. Record the meter reading.
12. Repeat step 10 three times. [The last three 1cc injections should be within +/- 5% of each other.]
13. Refer to the Temperature Conversion Chart below for the acceptable result range. [The average of the last three digital meter readings should fall within the range indicated on the chart. If so, the Model 411 is in calibration. If the average is not within range, proceed to the next step.]
14. Perform **FILM HEAT**. [Wait 1 hour before proceeding to step 15.]
15. Adjust **BRIDGE BALANCE** using trimmer tool until digital meter reads not less than 02, and not greater than 06.
16. Repeat calibration procedure. [If the average of the digital meter readings is still not within range, refer to the Model 411 Operation Manual, Calibration Check Trouble Shooting Section in Appendix A.]



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 12 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

TEMPERATURE CONVERSION CHART - MODEL 411

| Temperature °C | Digital Meter Response |
|----------------|------------------------|
| 16 | .064 to .086 |
| 17 | .070 to .094 |
| 18 | .076 to .102 |
| 19 | .082 to .112 |
| 20 | .090 to .122 |
| 21 | .097 to .131 |
| 22 | .105 to .143 |
| 23 | .115 to .155 |
| 24 | .124 to .168 |

7.6.2 Model 431

Use this test if your application requires frequent verification of instrument functionality. If the test results fall within the expected range, you may assume the instrument is functioning properly. This test **DOES NOT** calibrate the instrument. The Functional Test Kit, part number Y431 - 0902, is required for this procedure.

NOTE: Perform the functional test **ONLY** after a **SENSOR REGENERATION**.

Procedure:

1. Leave the thermos at stable room temperature for at least 2 hours. The temperature range for the test is 18 - 22 °C. Temperature fluctuations during the test procedure will produce erratic results.
2. Replace the intake filter disc.
3. Replace the septum.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 13 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

4. Plug the septum assembly into the instrument's intake and tighten the intake tube nut to ensure an airtight seal.
5. Attach a **ZERO AIR FILTER** to the septum assembly.
6. Press power **ON**.
7. Take 3 samples. If the average meter reading is less than .005, continue to step 8. If the average meter reading is greater than .005, stop here and refer to the Model 431 Operation Manual, Functional Test Trouble Shooting.
8. Note the temperature of the thermos.
9. Inject 1cc of mercury vapor.
10. Record the meter reading.
11. Repeat steps 9 and 10 three times. The results from last three 1cc injections should be within +/- 5% of each other. If not, refer to the Model 431 Operation Manual for proper syringe technique, and repeat the procedure.
12. Refer to the Temperature Conversion Chart given below for the acceptable range of results. The average of the last three digital meter readings should fall within the range shown in the chart. If the average is within the range, the JEROME 431 is functioning properly. If the average is not within range, proceed to the next step.
13. Perform **SENSOR REGENERATION**. While pressing **ZERO**, turn the **ZERO ADJUST**, using the trimmer tool until the digital meter reads 0.
14. Wait 1 hour before proceeding to step 15.
15. Repeat steps 9 to 12 of this procedure. If the average of the digital meter readings is still not within range, refer to the Model 431 Operation Manual, Functional Test Trouble Shooting Section in Appendix B.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 14 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

TEMPERATURE CONVERSION CHART - MODEL 431

| Temperature °C | Digital Meter Response |
|----------------|------------------------|
| 16 | .091 to .123 |
| 17 | .100 to .135 |
| 18 | .108 to .146 |
| 19 | .118 to .159 |
| 20 | .129 to .174 |
| 21 | .138 to .187 |
| 22 | .151 to .204 |
| 23 | .164 to .222 |
| 24 | .177 to .240 |

8.0 CALCULATIONS

The Jerome Models 411 and 431 are direct reading instruments. The readings are displayed in units of mg Hg/m³ and encompass the range from 0.001 to 0.999 mg Hg/m³.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 15 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, or corporate health and safety practices. Dispose of used filters and scrubbers in accordance with proper disposal procedures.

MSDS documents are included in **Appendix C** for metallic mercury and chemical constituents of the sampling train scrubber and exhaust filter components.

12.0 REFERENCES

Arizona Instrument Corporation, Jerome Division. 1989. *Jerome⁴³¹ Mercury Vapor Analyzer Operation Manual*.

Jerome Instrument Corporation. 1986. *Jerome⁴¹¹ Mercury Vapor Analyzer Operation Manual*.

13.0 APPENDICES

A - Calibration Check Troubleshooting

B - Functional Test Troubleshooting

C - Material Safety Data Sheets



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 16 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

APPENDIX A
Calibration Check Troubleshooting
SOP #2136
March 2001



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 17 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

CALIBRATION CHECK TROUBLE SHOOTING

If the proper results were not achieved during the calibration check procedure, go over the following to discover the cause:

- A. Ensure battery charger and line cord are unplugged.
- B. Perform a flow rate check, procedure page 9.
- C. Ensure calibration vessel temperature is stable.
- D. Ensure calibration vessel mercury drop is not oxidized.
- E. A clogged, bent, or contaminated syringe needle should be replaced.
- F. If the internal tubing is crimped or blocked, straighten or replace affected tubing.
- G. Ensure instrument's intake is not blocked with foreign matter.

If none of the above conditions exist, follow these steps to determine if the flow system is contaminated:

- Attach zero air filter.
- Press SAMPLE 3 times.
If the average reading is less than .005, there is no mercury contamination. If still greater than .005,
- Replace zero air filter.
- Press SAMPLE 3 times.
If average reading is less than .005, the old zero air filter was contaminated. If still greater than .005,
- Change internal filter system. [Refer to page 10.]
- Press SAMPLE 3 times.
If average reading is less than .005, the internal filter was contaminated. If still greater than .005,
- Please call Technical Service, Toll Free (800) 952-2566 for assistance.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 18 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

APPENDIX B
Functional Test Troubleshooting
SOP #2136
March 2001



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 19 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

FUNCTIONAL TEST TROUBLESHOOTING

If you don't achieve good results with the test procedure, go over the following:

- Ensure the thermos temperature is stable.
- Ensure there is no oxidation on the mercury drop in the thermos.
- Ensure the instrument's uptake is not blocked with foreign matter.
- Straighten or replace crimped or blocked internal tubing.

and...

- Use a new syringe needle.

If you find the above does not solve your problems, follow these steps to determine if your flow system is contaminated:

1. Insert your zero air filter in the instrument's intake and tighten the intake tube nut to ensure an airtight seal.
2. Take 3 samples.
If the average meter reading is less than .005, there is no mercury contamination. If the average meter reading is greater than .005, proceed to step 3.
3. Remove and replace the zero air filter.
4. Take 3 samples.
If the average meter reading is less than .005, the old zero air filter was contaminated. If still greater than .005, proceed to step 5.
5. Change the internal filters.
Refer to page 12 of the 431 Manual.
6. Take 3 more samples.
If the average meter reading is less than .005, the internal filters were contaminated.

If the average is still greater than .005 –

Please call Customer Service, Toll Free (800) 528-7411 for help.



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 20 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

APPENDIX C
Material Safety Data Sheets
SOP #2136
March 2001



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 21 of 23
REV: 0.0
DATE: 03/08/01

THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

INTRODUCTION
DESCRIPTION OF THE ANALYZER: The Model 411 and 431 Gold Film Mercury Vapor Analyzers are designed to measure mercury vapor in air. The Model 411 is a portable analyzer, while the Model 431 is a laboratory analyzer. Both analyzers use a gold film sensor to detect mercury vapor.

Section 1 - Description Data

Model 411 is a portable analyzer, while Model 431 is a laboratory analyzer. Both analyzers use a gold film sensor to detect mercury vapor. The Model 411 is designed for field use, while the Model 431 is designed for laboratory use. Both analyzers have a range of 0 to 1000 ppb. The Model 411 has a response time of 10 seconds, while the Model 431 has a response time of 1 minute. Both analyzers have a sensitivity of 1 ppb.

Section 2 - Field and Laboratory Data

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WASHINGTON, DC 20006

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SHEET DATA SHEET
MATERIAL

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Section 7 - Field and Laboratory Data

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U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

SOP: 2136
PAGE: 22 of 23
REV: 0.0
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THE OPERATION OF THE JEROME MODELS 411 and 431 GOLD FILM MERCURY VAPOR ANALYZERS

Before beginning, personnel should wear proper safety
equipment and clothing. Avoid contact with mercury.

Information

Section 1 - General Purpose

This document is intended to provide information on the
operation of the Jerome Models 411 and 431 Gold Film Mercury Vapor
Analyzers. It is intended for use by personnel who are responsible
for the operation of these analyzers.

Section 2 - General Purpose

The purpose of this document is to provide information on the
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Section 3 - Use and Application

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Section 4 - Physical Data

Chemical Formula: Hg
Molecular Weight: 200.59
Boiling Point: 356.73°C
Melting Point: -38.83°C
Density: 13.546 g/cm³
Vapor Pressure: 0.0012 mm Hg at 25°C

WATER TREATMENT UNIT (WTU) 2500
WATER TREATMENT UNIT (WTU) 2500
WATER TREATMENT UNIT (WTU) 2500

Manufacturer



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SAFETY DATA SHEET
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